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Application of water quality indices for assessment of influent and effluent wastewater from wastewater treatment plant of Oran City, Algeria

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ABSTRACT

Water quality assessment is a significant criterion in matching water demand and supply. In this research, two water quality indices (WQI) methods were applied to evaluate the influent and effluent water quality of the Oran municipal wastewater using nine parameters (temperature, pH, total suspended solids, biochemical oxygen demand, chemical oxygen demand, electrical conductivity, nitrate–nitrogen, phosphate and the daily flow) and two calculated quotients for data recorded in the years from 2011 to 2019. The results pointed that the quality of the treated wastewater was declined from good in the years 2011 and 2012 to poor between 2016 and 2019. For those last 4 y, water quality deteriorated to the point that most WQI indicated noticeable deviation from desirable levels, due to the impact of several anthropogenic activities with a higher level of pollution than its treatment capacity. This in turn makes the effluent water unusable for irrigation. Application of the WQI is suggested to be a very helpful tool that enables the public and decision-makers to understand and manipulate the water quality of any aquatic system with great flexibility in the variable's selection.

Keywords: Water quality indices; Municipal wastewater; Water quality assessment

1. Introduction

The availability of water in Algeria shows a great deal with spatial and temporal variability. The increase in population and expansion of economic activities undoubtedly leads to the increasing demand for water use for various purposes. Moreover, water resources in Algeria, especially in the last two decades, have also suffered from remarkable stress in terms of water quantity and quality due to urban expansion and climate change, which exerts a large influence on water resource vulnerability [1] as well as improper water use planning.

Water pollution in Algeria is also a considerable problem. Surface and underground water resources are polluted by uncontrolled discharging of untreated municipal wastewater, arising from industries and agricultural runoff. Moreover, about 93% of the urban area is connected to a sewage network [2]. However, according to the National Sanitation Office (January 2020), the installed capacities of 154 WWTPs (wastewater treatment plants) were virtually 10.4 million population equivalents. That is, more than 3/4 of the wastewater is released into the natural environment without any treatment. Furthermore, most of these WWTPs are not functioning properly or out of service,

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which increases the volume of untreated sewage being discharged into natural water bodies [3]. These conditions contribute to enlarging the gap between the available water resources and the water demand for domestic, agricultural, and industrial needs.

Recently, water reuse is widely applied around the world to close the loop between water supply and wastewater discarding. Effective water reuse necessitates the integration of water and domestic water supply functions. The flourishing development of this reliable water supply depends on treatment process reliability, economic and financial analyses, and public acceptance [4]. Wastewater reuse has been applied in agriculture, motivated by its sustainable availability, a decrease of fertilizer use, and undertaking the problems accompanying wastewater disposal [5]. The Algerian current water strategy and policy is to manage wastewater as a vital resource rather than a waste. According to the National Sanitation Office of Algeria (2021), the quantities of water treated and reused in agricultural irrigation reached a volume of 14.6 million m^3 for the irrigation of 11,000 ha. This explains the ambition of Algeria to soon treat a billion m^3 of wastewater for the irrigation of 100,000 ha.

Depending on the reuse objective, that is, discharge to surface or groundwater bodies, irrigation purposes, or industrial reuse, the effluent should meet established quality limitations at all times. Thus, it is essential to understand the influent variability and its impact on the treatment process to prevent the adverse health and environmental impacts of reused wastewater. Appropriately, the efficiency appraisal of wastewater treatment plants is difficult due to the presence of several chemicals, physical, and microbiological parameters that should be considered [6]. This makes a great challenge for the operators due to the complex interrelationships of the parameters [7]. Therefore, it is important to develop suitable indexing variables to thoroughly define wastewater quality and evaluate the treatment system's efficiency [8].

Various approaches to assess the water quality have been proposed, such as water quality indices (WQIs), multivariate statistical methods (cluster analysis, factor analysis), and recently, those based on fuzzy logic which is very useful for predicting the health index of rivers, especially in cases of temporal-spatial changes [9]. WQIs are being widely used in water quality assessment studies and have played an increasingly important role in water resource management [10]. WQI is an efficient mechanism to express the overall condition of wastewater quality by using values of various parameters measured, which can act as a sign of water pollution [11,12]. In addition to determining water quality, trends should be analyzed to determine whether the measured values of a water quality variable decrease or increase over a period of time [13]. Nevertheless, few researchers have addressed the issue of WQI in WWTP due to: (i) the complex interrelationships of the parameters and (ii) the natural temporal variation that makes it difficult to initiate standardized one-to-one relationships which describe flows throughout all anticipated conditions [14].

Accordingly, the main purpose of this research is to develop a wastewater evaluation procedure for a regional treatment facility. The study objectively evaluated the influent and effluent quality of wastewater treatment plants in Oran City (OWWTP) by using two WQIs during 2011–2019 to investigate the appropriateness of the effluent quality for irrigation purposes.

2. Materials and methods

2.1. Description of the Oran wastewater treatment plant

The OWWTP has been functional since 2009. The treatment plant was designed to service 1. 5 million residential connections and to treat the municipal wastewater with a daily volume of 270,096 m^3 of wastewater to domestic dominance by the system-activated sludge. The wastewater treatment plant consists of preliminary, secondary, and tertiary treatment systems (Fig. 1). Screenings and grit removal units were designed for preliminary treatment. For secondary treatment, the oxidation ditch process,

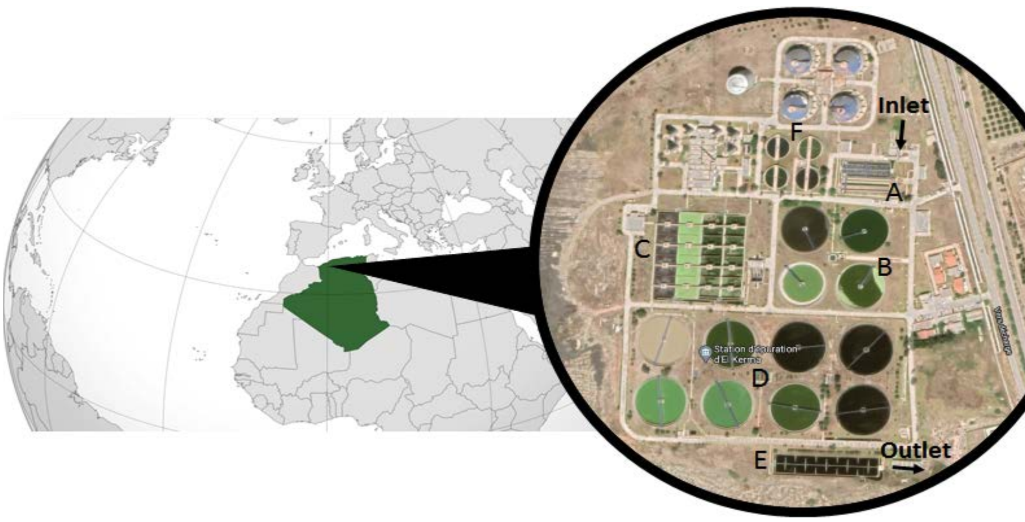


Fig. 1. The Oran wastewater treatment plant localization (latitude: 35.60, longitude: –0.58). A: Preliminary treatment; B: Primary settling; C: Biological treatment; D: Clarification; E: Disinfection; F: Sludge treatment.

coupled with clarification units, was designed to biologically remove organic and nutrient materials from the wastewater. Following clarification, the effluent flows to the chlorination and disinfection unit for tertiary treatment. The final effluent is discharged to a stream.

2.2. Monitored parameters and analytical methods

For this study, physicochemical parameters derived from analyses were carried out by the laboratory of OWWTP. In all, 1976 samples were collected between 01/07/2011 and 21/12/2019, for influent and effluent based on daily monitoring data to detect the temporal changes in their water quality. However, the data for 2015 were missing due to geotechnical problems in the plant. Samples were collected from 10 cm below the surface of the water using a Silicon/Teflon water pump. For influent, six (6) parameters were measured: temperature, pH, total suspended solids (TSS), biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), and daily flow. Also, biodegradability index (K_1 = COD/BOD_5) and production index of excess sludge (K_2 = TSS/BOD_5), were calculated. For effluent, eight (8) measured parameters were treated: temperature, pH, TSS, BOD_5, COD, electrical conductivity (EC), nitrate–nitrogen (NO_3–N), and phosphate (PO_4–P). Temperature, EC, and pH of surface water were measured immediately after collection using HQ40D Portable Multi-Parameter Meters (Hach Company, USA). All analytical methods applied for other parameters were following the standard methods for examining water and wastewater [15].

2.3. Statistical analysis of the data

As in most wastewater treatment plants, daily monitoring was carried out to ensure the smooth functioning of the system that generates a large number of highly variable data. However, the accuracy of this data is necessary to assess the efficiency and purification performance of the plant [16]. To avoid any distortion of information obtained from the raw data, it is imperative to characterize abnormal values that are usually the result of (i) reading or handling error during measurement and (ii) accidental spills of several pollutants from industrial sources in the sewer system. As defined by several authors, "An outlying observation (outlier), is one that appears to deviate from other members of the sample in which it occurs" [17]. The identification of outliers was done using the Box Plot method defined by Tukey [18]. The box's height is that of the interquartile distance ($Q_3 - Q_1$), and the whiskers are usually based on 1.5 times the box's height. In this case, a value is atypical if it exceeds the interquartile gap below the 1st quartile (Q_1) or above the 3rd quartile (Q_3). According to Tukey [18], value 1.5 is a pragmatic value of the rule of thumb, which has a probabilistic reason [19]. In this study, outliers are calculating as:

- Minor outlier (Min. Out.) = $Q_1 - 1.5 \times (Q_3 - Q_1)$
- Major outlier (Maj. Out.) = $Q_3 + 1.5 \times (Q_3 - Q_1)$

After detection, the outliers must be removed, because if undetected, they could influence calculations [20].

To check if the data followed a normal distribution, the graph of normal quantiles was performed, using the quantile regression approach. With this method, a regression model is developed for selected quantiles of the limited distribution of the response variable [21]. This approach, continues to be an interesting tool for statistical studies, as it accounts for the impact of an explanatory variable on different quantiles of a dependent variable [22]. If the linear relation is obtained from this graph, the data follow a normal distribution. For this step, the verification of the normality testing has been made by Excel. Descriptive statistics of the influent and effluent parameters were tabulated in Tables 1 and 2.

2.4. Application of the WQI

The WQI is the most appropriate way to express water quality. These WQI can summarize a lot of information into a single value to represent the data in a shortened and simplified form [23], that is, understandable and usable by the public [24].

According to the literature, there are several methods for developing WQI. In this study, two methods, which are the Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) and Weighted Arithmetic Water Quality Index Method (WAWQIM), were implemented for the determination of WQI of influent and effluent of OWWTP to confirm if the water outlet is

Table 1
Descriptive statistics for the influent parameters measured

Parameters	pH	Temp. (°C)	TSS (mg/L)	BOD_5 (mg/L)	COD (mg/L)	Daily flow (m^3/d)	K_1	K_2
Min.	4.5	5.0	25	15	82	157	0.6	0.10
Q_1	7.4	17.5	190	200	395	52,604	1.6	0.70
Median	7.6	21.2	248	270	510	68,818	1.9	0.90
Q_3	7.8	25.4	320	320	627	84,680	2.3	1.20
Max.	9.6	31.4	1656	888	1584	145,173	34.4	26.4
Mean	7.6	20.8	264	268	515	65,175	2.1	1.10
Min. Out.	6.87	5.65	–5	20	47	4,490	0.40	–0.08
Maj. Out.	8.31	37.3	515	500	974	–	3.5	2.0
Permissible limit	$6.5 \leq pH \leq 9$	12–32	359	339	848	>27,000	$1.5 \leq K_1 \leq 2.5$	$0.8 \leq K_2 \leq 1.2$

Table 2
Descriptive statistics for the effluent parameters measured

Parameter	pH	Temp.	TSS (mg/L)	BOD_5 (mg/L)	COD (mg/L)	Conductivity (µS/cm)	NO_3 (mg/L)	PO_4 (mg/L)
Min.	6.10	4.70	2	1	2	230	0.0	0.0
Q_1	7.50	15.1	8	8	38	2,280	2.1	1.3
Median	7.70	19.2	13	12	54	2,560	6.0	3.7
Q_3	8.01	24.8	20	20	78	2,880	17.7	7.5
Max.	8.90	31.3	385	280	660	4,870	110.5	77.4
Mean	7.70	19.3	21	23	72	2,596	13.0	5.0
Min. Out.	6.67	0.55	–10	–10.3	–21.04	1,380	–21.1	–8.09
Maj. Out.	8.75	39.35	38.00	38.5	137.43	3,780	40.91	16.86
Permissible limit	6.5 ≤ pH ≤ 8.5	30	35	25	125	3,000	30	5

affected by the water inlet of the OWWTP and whether the effluent of treated wastewater is suitable for irrigation purposes [25]. These two methods were chosen because of their reputation in assessing water quality used by various scientists in different countries [25]. To facilitate the comparison of the two methodologies, the same parameters of effluent were used in both of them to evaluate the water quality status [26]. For the two methods, the effluent WQI was calculated by using the standards of treated wastewater used for irrigation purposes recommended by the World Health Organization (WHO). However, the influent WQI was calculated based on the limit values given in the technical prescriptions of the realization and management contract of the OWWTP.

2.4.1. Canadian Council of Ministers of the Environment Water Quality Index

This method allows the synthesis of multivariable data and provides a flexible index template adaptable to the site-specificity [27]. Fig. 2 presents the WQI calculated in a three-dimensional space by summing three factors (F_1, F_2, and F_3) as vectors [28].

The three elements were calculated as follows [14]:

Scope "F_1": is the percentage of measured parameters that do not meet their limit at least once during the time period (failed parameters), relative to the total number of parameters measured.

$$F_1 = \frac{\text{number of failed parameters}}{\text{total number of parameters}} \times 100 \quad (1)$$

Frequency "F_2": is the percentage of individual tests that do not meet their limit (failed tests).

$$F_2 = \frac{\text{number of failed tests}}{\text{total number of tests}} \times 100 \quad (2)$$

Amplitude "F_3": is the number of failed test values that do not meet their limit. F_3 is calculated in three steps:

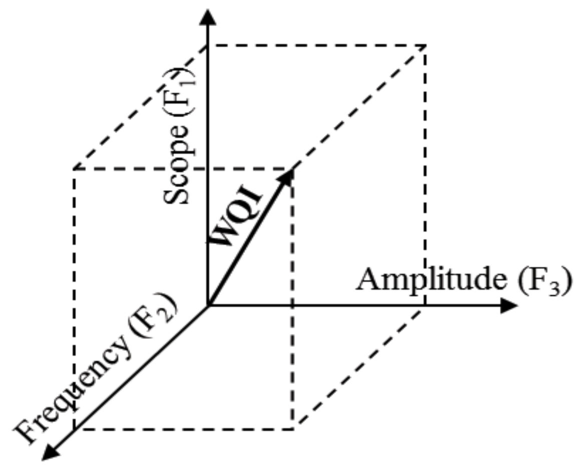


Fig. 2. Conceptual model of the CCME WQI.

(a) The number of times an individual concentration is greater than (or less than in case of a minimum guideline) the guideline is called an "excursion" and is expressed as follows.

(a1) When the test value must not exceed the guideline:

$$\text{Excursion}_i = \frac{\text{failed test value}_i}{\text{limitation}_j} - 1 \quad (3)$$

(a2) For the cases in which the test value must not fall below the guideline:

$$\text{Excursion}_i = \frac{\text{limitation}_j}{\text{failed test value}_i} - 1 \quad (4)$$

(b) The collective amount, in case of individual tests being out of compliance, is calculated by adding the excursions of individual tests from their guidelines and dividing their sum by the total number of tests. This parameter, known as the normalized sum of excursions (nse), is calculated as:

$$\text{nse} = \frac{\sum_{i=1}^{n} \text{Excursion}_i}{\text{total number of tests}} \tag{5}$$

F_3 is then calculated by an asymptotic function which scales the normalized sum of excursions (nse) from objectives to yield a value between 0 and 100.

$$F_3 = \frac{\text{nes}}{0.01\text{nse} + 0.01} \tag{6}$$

The CWQI is then calculated as:

$$\text{CWQI} = 100 - \frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732} \tag{7}$$

CCME WQI is considered a dimensionless number between 0 and 100, and it is ranked in the following categories (Table 3):

2.4.2. Weighted Arithmetic Water Quality Index Method

This method was initially developed by Horton in 1965, then by Brown's group in the early 1970s. Based on relative weights by individual parameters, it has been broadly applied in African, Asian, and European countries, to monitor changes in water quality [29]. According to this method, the water quality was classified as related to the degree of purity using the most measured water quality variables [29]. The numerical value of relative weight (W_i), specific to each physicochemical parameter, is expressed by [30]:

$$W_i = \frac{k}{S_i} \tag{8}$$

where k = proportionality constant, calculated using the following equation:

$$k = \frac{1}{\sum_{i=1}^{n} \left(1/S_i\right)} \tag{9}$$

Table 3
Water quality category based on CCME WQI

CWQI	Quality range	Water categories
95–100	Excellent	Conditions very close to pristine levels
80–94	Good	Conditions rarely deviate from desirable levels
60–79	Fair	Conditions sometimes deviate from desirable levels
45–59	Marginal	Conditions often deviate from desirable levels
0–44	Poor	Conditions usually deviate from desirable levels

S_i = Standard permissible value of each parameter.

Further, the quality rating (q_i) of each parameter can be calculated by:

$$Q_i = 100\frac{\left[V_i - V_{\text{io}}\right]}{\left[S_i - V_{\text{io}}\right]} \tag{10}$$

V_i = Estimated value of each parameter at a given sampling station; V_{io} = Ideal value of each parameter in pure water. That is, 0 for all parameters except pH and dissolved oxygen (7.0 and 14.6 mg/L, respectively); n = number of water quality parameters.

The WAWQI was calculated by aggregating the quality rating with the unit weight linearly:

$$\text{WAWQI} = \frac{\sum_{i=1}^{n} W_i Q_i}{\sum_{i=1}^{n} W_i} \tag{11}$$

Once the WAWQI value has been calculated, water quality is then ranked in the following categories (Table 4):

For treating huge amounts of data, Excel spreadsheets have been developed for the WQI calculations. The standard values of various parameters measured for the calculation of WQI are presented in Tables 1 and 2.

3. Results and discussion

3.1. Outlier detection and normality testing

The distribution of influent and effluent raw data was represented by Figs. 3 and 4. Practically for all the influent parameters, the Box Plots representations indicate that the measured values' distributions are symmetrical, except for TSS and BOD_5, where distributions are asymmetric spread towards the large values for the first and the small values for the second. Regarding effluent parameters, the Box Plots indicate that the distribution is asymmetric spread towards large values.

Very few outliers were identified when using the Tukey method [18]. Only 3.6% and 4.5% were removed from the influent and effluent measured values, respectively. After detection and removing outliers, the quantile regression approach has been used for normality testing. As observed from Figs. 5 and 6, the data of the influent and effluent parameters follow a normal distribution. The regression coefficient (R^2) varied from 0.97 to 0.99 for the influent parameters and from 0.83 to 0.99 for the effluent parameters.

Table 4
Water quality category based on WAWQIM

WAWQI	Water quality range
0–25	Excellent water quality
26–50	Good water quality
51–75	Poor water quality
76–100	Bad water quality
>100	Very bad water quality

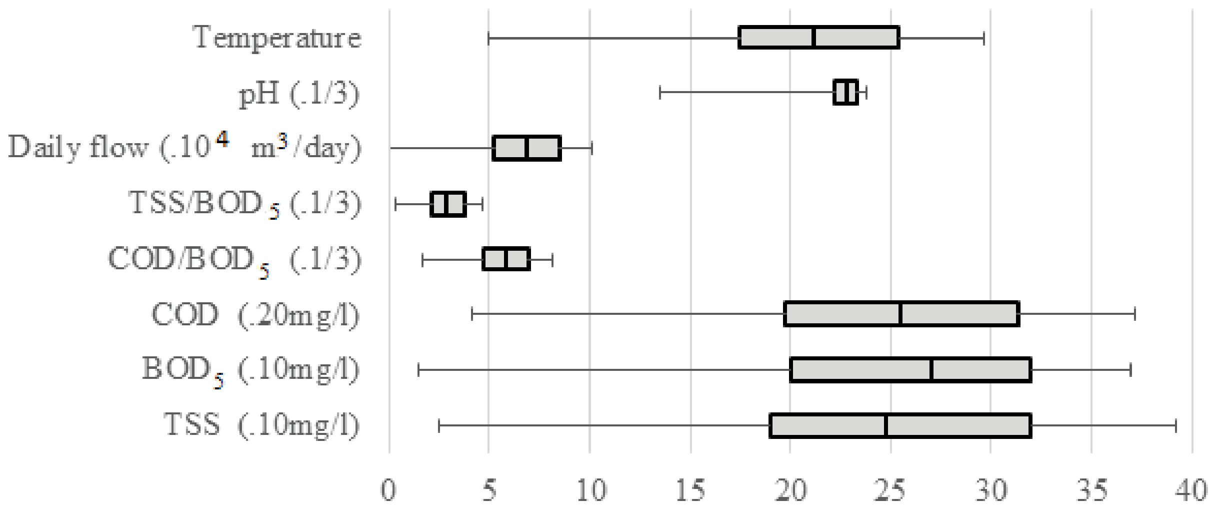


Fig. 3. Box Plot of influent parameters.

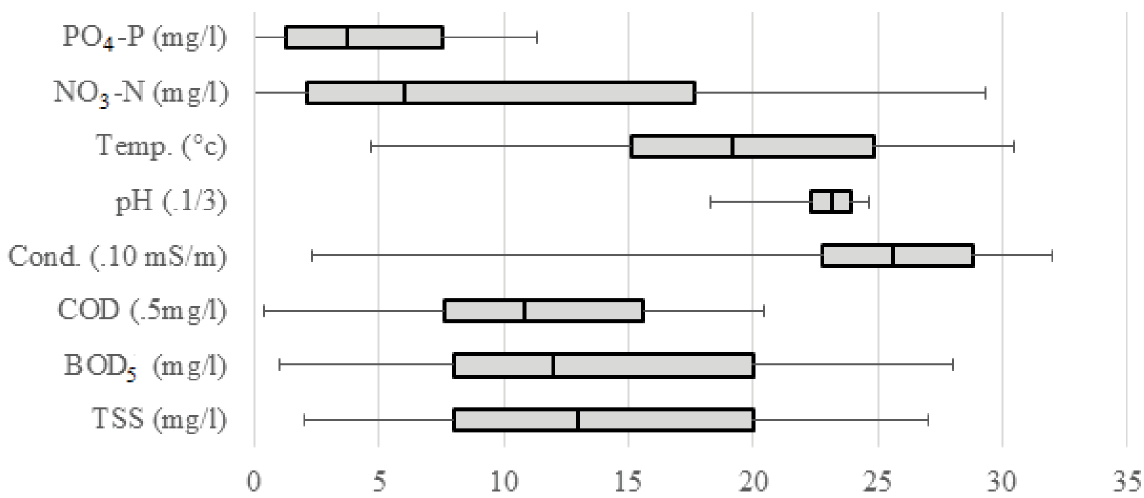
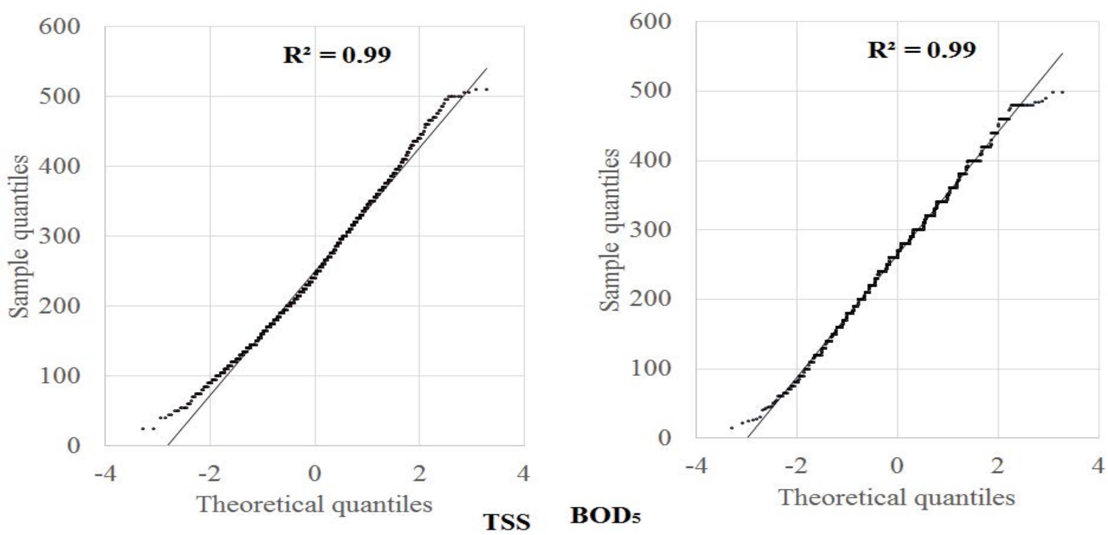


Fig. 4. Box Plot of effluent parameters.



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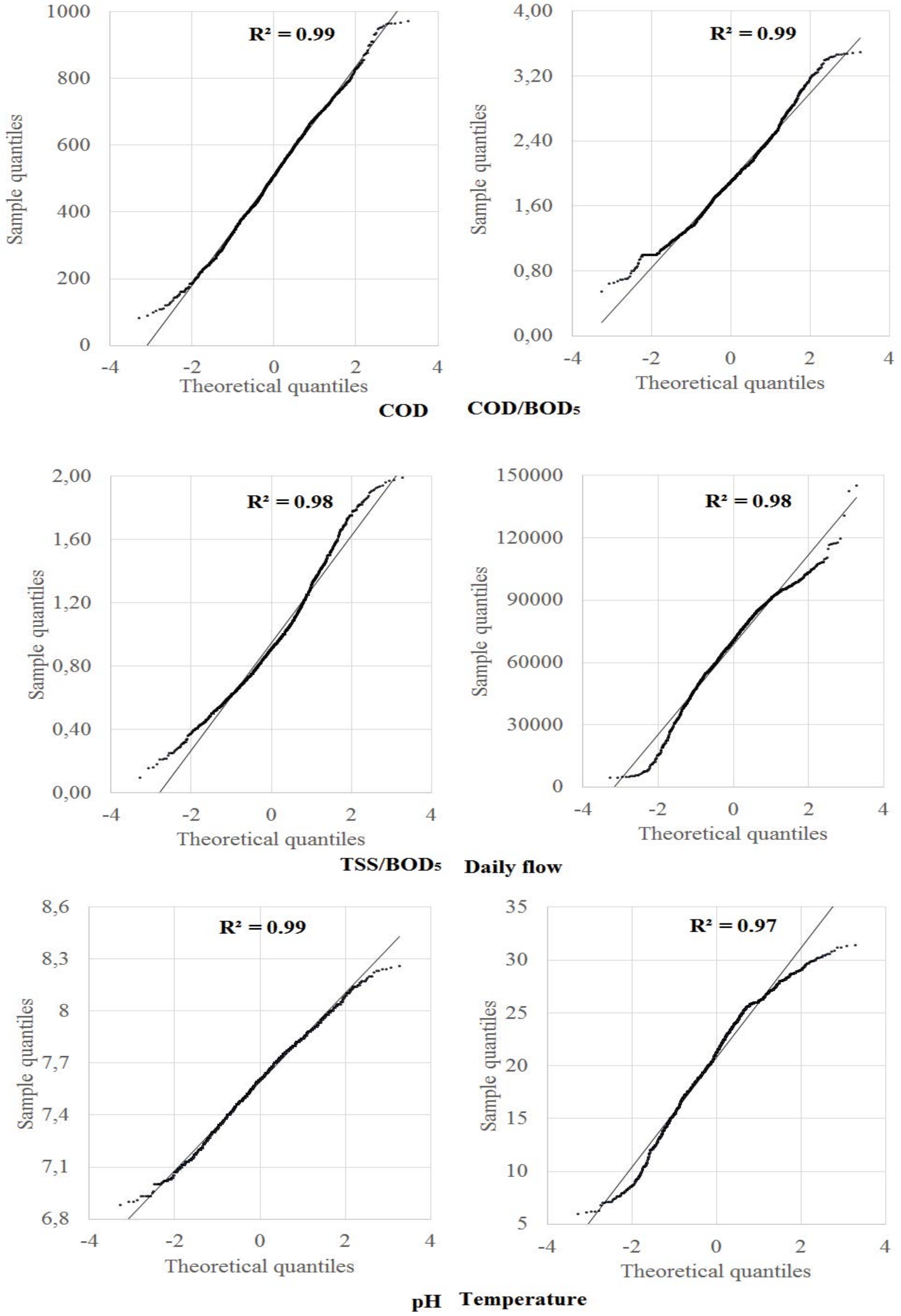
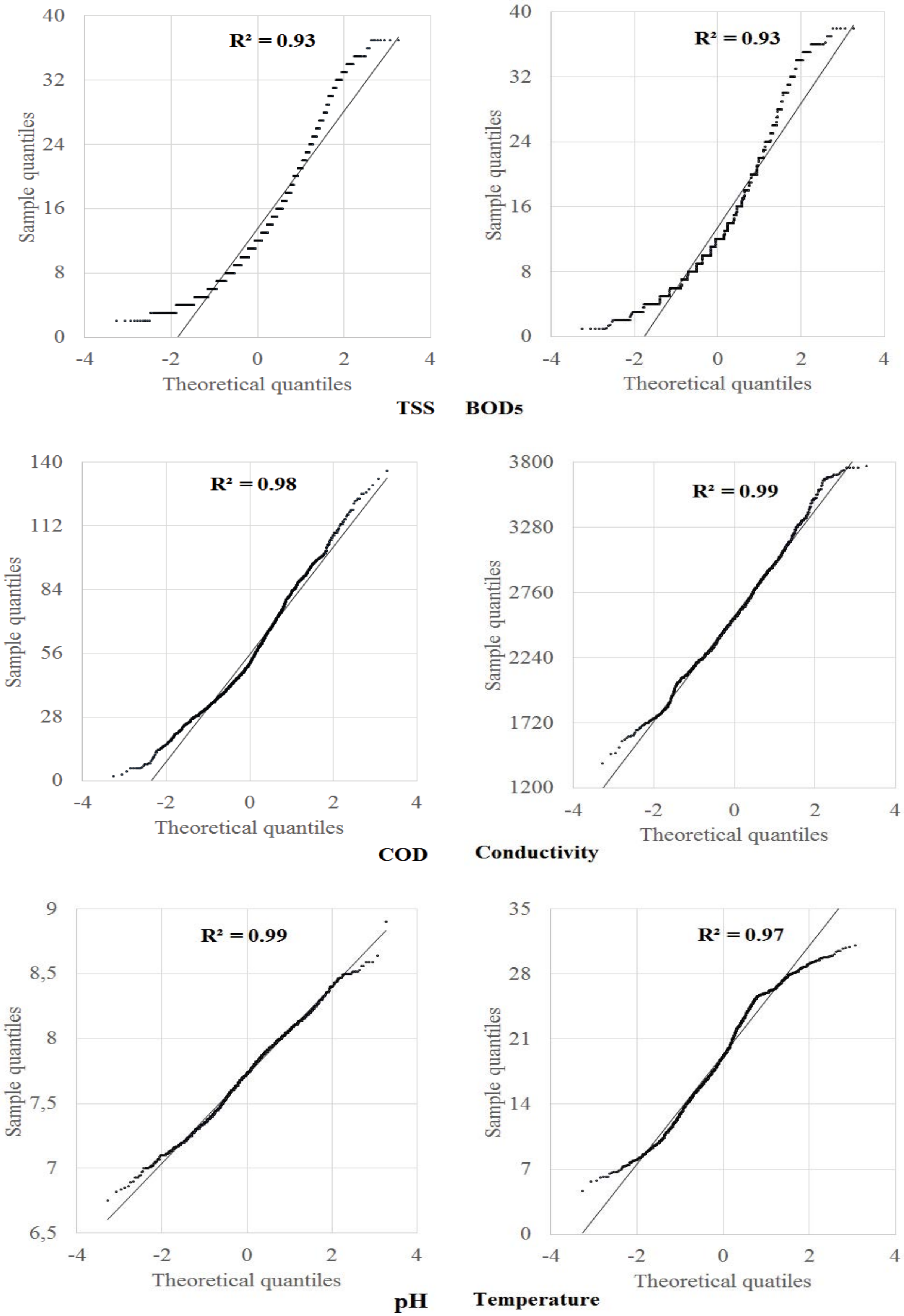


Fig. 5. Normal quantile–quantile plot of influent parameters.


R² = 0.93
Sample quantiles
Theoretical quantiles
TSS
R² = 0.93
Sample quantiles
Theoretical quantiles
BOD5
R² = 0.98
Sample quantiles
Theoretical quantiles
COD
R² = 0.99
Sample quantiles
Theoretical quantiles
Conductivity
R² = 0.99
Sample quantiles
Theoretical quantiles
pH
R² = 0.97
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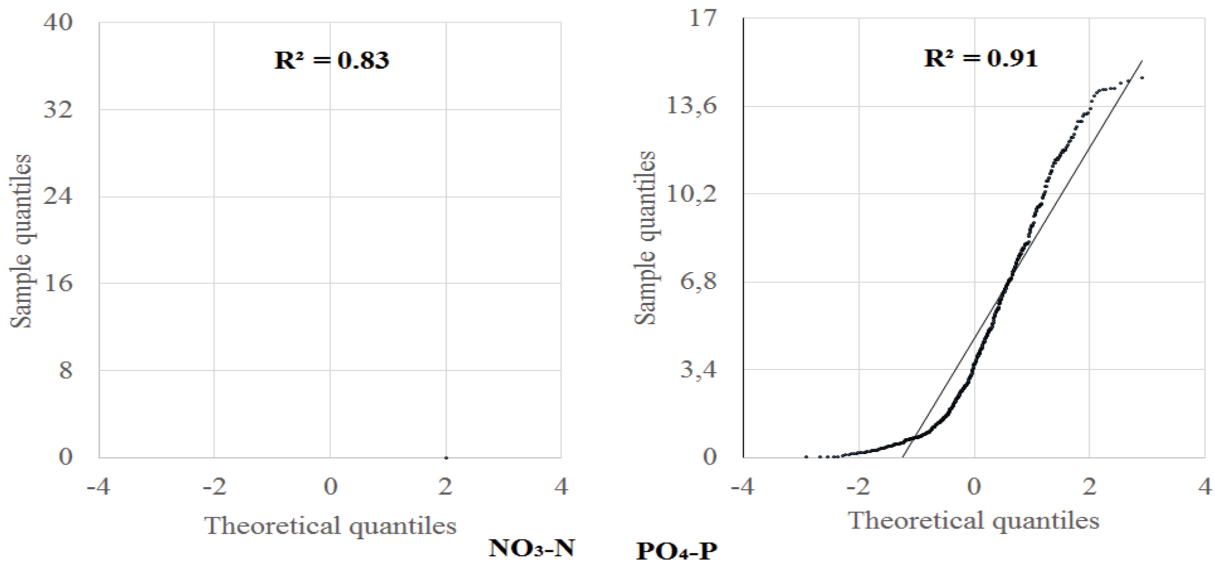

Fig. 6. Normal quantile–quantile plot of effluent parameters.

3.2. General characteristics of OWWTP effluent quality

The quality of the water for irrigation may influence both crop yields and soil's physical conditions. The selected physical and chemical parameters which determine the quality of irrigation water and are included in the WQI calculation are displayed in Table 2. The mean of the effluent wastewater quality parameters in the selected OWWTP over the monitoring period is presented with mean, minimum and maximum values. The mean effluent pH values ranged from 6.10 to 8.90 which indicates the slightly acidic to alkaline nature of effluent wastewater with slightly different from standard values. The mean effluent TSS value varies in the range of 2 to 385 mg/L which is above the allowable limit of 30 mg/L as WHO standard. The BOD_5 values of 1 and 280 mg/L were recorded as the minimum and maximum values, respectively, with an exceeding allowable limit of 25 mg/L.

In the studied plant, the mean effluent COD values were ranged from 2 to 660 mg/L as a minimum and maximum concentrations, respectively. The maximum allowable limit of the COD to irrigate crops is specified as 125 mg/L. The mean effluent conductivity was 2,596 µS/cm and ranged from 230 to 4,870 µS/cm. This means that the maximum value exceeded the allowable limit of 3,000 µS/cm. The mean effluent value of NO_3^- for OWWTP was ranged from 0.0 to 110 mg/L (higher than the standard value) with the mean value of 13 mg/L. PO_4^{-3} effluent concentration was ranged between 1.3 and 77.4 mg/L with a mean value of 5 mg/L which is below the allowable limit.

3.3. Assessment of the wastewater treatment plant effluent using water quality indices

The results of the OWWTP monitoring program comprise a complex matrix of physicochemical parameters, which individually cannot provide a reliable temporal evaluation of the effluent wastewater quality. To overcome this challenging issue, the two WQIs were applied to summarize many monitored parameters into one simple term.

3.3.1. Effluent water from OWWTP

As shown in Table 5, the WQI varied from marginal, fair, and good for the CCME WQI and from very bad, bad, poor, good, and excellent for the WAWQIM. For this last method, because of the missing data, only 243 samples spread over the 8 y could be used to estimate the WAWQI. According to both methods, water quality in 2011 and 2012 was good for irrigation usage. It was usually protected but occasionally impaired, that is, conditions sometimes deviated from desirable levels to be used for irrigation. Both methods also agree that for the last 4 y (between 2016 and 2019) there was some concordance regarding the water quality. Indeed, for the years 2016, 2017, and 2019, the water quality was marginal according to CCME WQI, and it varied from poor to very bad according to WAWQIM. For those years, water quality deteriorated to the point that most WQI indicated that conditions often deviated from desirable levels, which means that the water is unusable for irrigation. This convergence of results is valid even for the year 2018, where the first method gave fair while the second one indicated poor quality. This implies the water quality was frequently threatened or impaired.

However, discrepancies in the results remain for the years 2013 and 2014. The CCME WQI method gave values that were in the marginal category, while the results obtained from the WAWQIM method indicated that the water quality was good. Those discrepancies result from the limitations and imperfections of each of the two methods. Concerning CCME WQI, as mentioned above and as is shown in Table 5, the value of WQI is strongly influenced by the term F_1. Determination of the effluent water quality by the two methods concluded that the quality of treated water was inadequate for agricultural usage, except for the first 2 y of operation of the OWWTP, where water quality allowed its use for irrigation. The possible explanation for this situation was attributed to mechanical, electrical, or other failures and dysfunctions. Consequently, it was considered more appropriate to determine the WQI of the inlet point (influent waters).

3.3.2. Influent water from OWWTP

By developing the CCME WWQI method, it was noted that all influent values of water quality are marginal when the calculated indices were ranged within 48 and 56 (Table 6). This means that the conditions frequently deviated from the limit values specified in the technical prescriptions and the effective functioning of the plant. This explains, in part, the unsatisfying results of the effluent WQI.

The failed test analysis reveals that the values of the three parameters; conductivity, the concentration of PO_4–P, and BOD_5, are largely responsible for effluent unsatisfactory WQI with 40%, 29%, and 24% of failed tests, respectively. Concerning the influent WQI, the three largely responsible parameters are the biodegradability index (K_1 = COD/BOD_5), daily flow, and BOD_5, with 39%, 25%, and 17% of failed tests, respectively. The poor reduction in the conductivity of the effluent can be linked to the fact that the quotient K_1 of the influent is not in line with standard values prescribed by WHO due to the high load of mineral substances. This reinforces the idea that there are strong associations between the influent and the effluent of the OWWTP.

4. Conclusion

The temporal variations of nine measured parameters and two calculated quotients were studied and analyzed for the wastewater of the influent and effluent discharged from OWWTP from July 2011 to December 2019 to know whether the treated water is suitable for irrigation purposes or not. By applying the two water quality indices methods; CCME WQI and WAWQIM, the results from calculations showed, firstly, that for the effluent, both methods gave the WQI vary from marginal (2013, 2014, 2016, 2017, and 2019), fair (2012 and 2018), and good (2011) for the CCME WQI,

Table 5
Effluent WQI evolution

Years		2011	2012	2013	2014	2016	2017	2018	2019
					CCME WQI				
Samples		94	204	331	326	245	255	328	193
Total number of tests		574	1,219	2,110	1,728	1,522	1,489	2,088	1,260
Number of failed tests		1	10	70	201	168	66	122	66
F_1		12.5	**37.5**	**62.5**	75	**87.5**	75	**37.5**	75
F_2		0.17	**0.82**	**3.32**	**11.63**	**11.04**	**4.43**	**5.84**	**5.24**
F_3		**0.126**	**0.118**	**0.399**	**1.390**	**4.773**	**2.532**	**2.420**	**1.664**
WQI		**93**	**78**	**64**	**56**	**49**	**57**	**78**	**57**
Quality range		Good	Fair	Marginal	Marginal	Marginal	Marginal	Fair	Marginal
					WAWQIM				
Samples		4	18	40	56	36	14	26	49
Excellent		0	0	3	4	0	0	4	0
Good		**100**	**67**	**88**	**71**	19	14	8	29
Poor	%	0	28	8	21	28	21	**42**	**35**
Bad		0	6	3	4	22	7	31	27
Very bad		0	0	0	0	**31**	**57**	15	10

Table 6
Influent WQI evolution

Years	2011	2012	2013	2014	2016	2017	2018	2019
Samples	94	204	331	326	245	255	328	193
Total number of tests	700	1,551	2,527	2,531	1,874	1,925	2,522	1,519
Number of failed tests	121	214	460	344	322	364	429	261
F_1	75	75	**87.5**	**87.5**	**87.5**	**87.5**	**87.5**	**75**
F_2	**17.29**	**13.80**	**18.20**	**13.59**	**17.18**	**18.91**	**17.01**	**19.16**
F_3	**2.911**	**2.559**	**5.146**	**2.469**	**5.751**	**5.061**	**5.426**	**5.390**
WQI	**56**	**56**	**48**	**49**	**48**	**48**	**48**	**55**

and from very bad, bad, poor, good and excellent for the WAWQIM, which in turn indicated that conditions often deviated from desirable levels and treated water is unusable for irrigation.

Secondly, for the influent, WQI values are marginal, which means that OWWTP receives wastewater with a higher pollutant load than the treatment process with which the different equipment has been sized. This necessarily caused a degradation in the performance of the treatment process. There are strong associations between the water qualities of the influent and the effluent waters from OWWTP. It is worth noting that every method used in this study could be applied easily and become a reference for similar projects to determine the performance of any other wastewater treatment plant.

Recommendations

For monitoring the performance of wastewater treatment plants and also for evaluating temporal and spatial changes in water quality development, an artificial intelligence model should be developed to evaluate the characterization of the physicochemical parameters of raw and purified wastewater as well as the prediction of the quality indices of purified water. This will be a question of developing a roadmap that would encompass a series of procedures that should apply to all domestic wastewater treatment plants in Algeria and elsewhere.

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